

The University of Chicago

FACTOR ANALYSIS OF MEMORY ABILITY

A PART OF A DISSERTATION SUBMITTED TO
THE FACULTY OF THE DIVISION OF THE
BIOLOGICAL SCIENCES IN CANDIDACY FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF PSYCHOLOGY

1937

By
HILDING BROR CARLSON

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BY HILDING B. CARLSON

This study is an attempt to analyze memory ability with the use of the Thurstone multiple factor technique.¹ The experimental conditions were arranged in order to test the truth of two very common assumptions: (1) that memory ability can be divided into rote and logical memory, and (2) that rote memory can further be divided into a visual and a vocal factor. The term vocal, as used here, refers to the kinaesthetic and auditory cues that result if an individual pronounces a word, even though inaudibly, inasmuch as there is no adequate means of differentiating them in this circumstance.

That material may be memorized by at least two methods: the rote and the logical, is well known (1). Since the efficiency of memorization may vary with the method used and since individuals may differ in the degree to which they utilize these methods, individual differences in memory ability may be due to differences in the relative effectiveness of the method utilized. In other words, there is the hypothesis that memory ability may be divided into at least two factors: rote and logical. This general assumption of the existence of these two types will be tested.

Even though the material has been presented visually in

¹ From the Psychological Laboratory of the University of Chicago.

The writer wishes to acknowledge his indebtedness to Dr. Frederick H. Wezeman, President, Chicago Christian High School and Junior College, where the majority of the students who participated in this experiment were obtained.

this experiment, since this is the most feasible manner, the mode of presentation does not necessarily determine the modality which will be adopted by a subject in memorizing that material (3). The efficiency of memorization may vary with the sense modality utilized, even though the group methods previously used to determine this have given inconsistent results. Since individuals may differ in the degree to which they use various modes, individual differences in memory ability may be due to differences in the relative effectiveness of the sense modality used. There is the hypothesis, then, that memory ability may be divided into visual and vocal memory. This assumption will also be tested.

As stated, previous experiments comparing memory efficiency of the different senses have found no consistent differences between groups. There is the possibility that vision is superior for some individuals, and audition for others, and that the two cancel each other for the group as a whole. The group method merely discovers what is true for the group as a whole, and gives no way of discovering the possibility of intra-group variability in respect to the factor studied. The multiple factor method, developed in recent years, however, does this sort of thing. It is a method of isolating the various abilities in respect to which individuals may be classed into types of the general sort. With this new technique, it may be possible to demonstrate that memory efficiency does vary with the sense modality utilized.

One way of attempting to elicit the postulated logical, visual, and vocal factors would be to vary the character of the material, and this has been done here. Various kinds of material might have been utilized, but since words are much better, especially for presentation, they have been used. Their use necessitated employing the recognition method of testing memory. Recall or relearning might have been employed, if words and nonsense syllables were used, but this would have necessitated lists of nonsense syllables of such character that some would have pronounced vocal characteristics and others visual, and there is no available criterion for selecting nonsense syllables having these characteristics.

With the employment of the recognition method, specific distractors had to be used in order to obtain a differentiation. Accordingly, it was necessary to make up lists systematically varying the distractors in visual appearance, vocality, and meaning, and in their combinations, in order that each mode be separately favored. In order to do this, it was necessary to select groups of words of such character that other words could be found that have particular relationships to the first words. One group of words was selected because for each word a synonym could be found; another group of words was chosen because for each word a homonym could be found. In like manner, other groups of words were selected as indicated in Table 1. This table also gives an example of each group.

TABLE 1

RELATION BETWEEN THE WORDS OF A PAIR IN THE EXPOSURE AND RECOGNITION LISTS

Group	Number Words in Each Recognition List	Words Alike in Respect to:	Words Different in Respect to:	Example
A	56		Visual appearance Vocality Meaning	cruel diagonal
B	50	Vocality	Visual appearance Meaning	no know
C	48	Meaning	Visual appearance Vocality	rely depend
D	24	Visual appearance	Vocality Meaning	ob'ject ob-ject'
E	44	Vocality Meaning	Visual appearance	through thru
F	26	Visual appearance Meaning	Vocality	con'tem-plate con-tem'plate
G	66	Visual appearance Vocality	Meaning	bark (of dog) bark (of tree)

Inasmuch as the words were presented visually, and the words of a pair in Groups D and F are alike in spelling but

different in vocality, it was necessary to designate their pronunciation in some way in order to differentiate them. It was entirely arbitrary as to how this was to be done. Accordingly, the simplest method was chosen, namely, by spelling the words in syllables and indicating the place of the spoken accent by the usual character. This manner of designation excluded words which have two different pronunciations but which can be differentiated only by the use of phonetic symbols. It is probable that the majority of subjects are not familiar enough with these symbols to use them with facility. In addition, their use would have resulted in additional visual cues.

Ideally, in Group G both words of a pair should have the same visual appearance and vocality but should differ in meaning. Because of the impossibility of designating a specific meaning for these words without the use of context, it was necessary to indicate the meaning intended. This was done by placing the specific meaning in parentheses, as 'bark (of dog)' for one and 'bark (of tree)' for the other. This group does not adequately fulfil the logical experimental requirements inasmuch as subjects could react to the words in the parentheses, as '(of dog)' and '(of tree)' and disregard the word 'bark' entirely. To minimize this possibility, the words in parentheses were made less conspicuous by using smaller type.

One of each pair of words was to be included in an exposure list. Both words of the pair were to be included in a recognition list, the word not used in the exposure list serving as a distractor for the other. The relation between the associated words in a recognition list was to be constant, so that the use of a particular mode or combination of modes is favored. It is not essential that the lists be equal in length because we are concerned only with the relative scores made within the group. However, it was important to make the lists difficult enough to insure differentiation among the subjects. At the same time, it was undesirable to make them so difficult that the subjects would become discouraged and lose interest in the experiment. After preliminary trials with a small group of subjects, an attempt was made to make the lists of such

length that the average score would approximate 75 percent correct recognition. The number of words used in the recognition lists for each group in the experiment proper is included in Table 1.

In this experiment, where the material, the procedure, and the method of analysis have been definitely restricted, a single list of each group of words would not be sufficient for the solution of the problem. There were three factors determining the number of lists: enough lists to insure a reasonable degree of reliability; avoidance of making the experiment too long; and the number of pairs of words in each group that can be procured. Five lists were considered sufficient to satisfy the first and yet comply with the second. Due to the third, however, only four lists could be made for Group D.

In order to make up these lists with all the requirements and limitations imposed, it was necessary to disregard certain differences among the words, such as syllabic length, parts of speech, etc. No word is used twice. All the words were checked against Webster's Unabridged Dictionary (7). An attempt was made to select from all the available pairs of words those which were considered to be most familiar to the subjects.

The order of arrangement of the words in both lists is by chance except that one member of the pair of words does not immediately follow the other in the recognition list. The words in the recognition lists were numbered. The lists were labeled A1, A2, A3, A4, A5, B1, B2, etc.

To make it possible to give the experiment to a group of subjects at one time and to control the exposure time for each word, the words were serially exposed on a screen by means of a film and a projection machine. Light letters on a dark background were used instead of the more usual black letters on a light background. This was done to save time and expense but it should in no way influence the results inasmuch as it is a constant factor for all subjects and for all words.

The exposure list was presented to the subjects. They were told that a series of words would be shown on the screen.

They were instructed to memorize the words so as to be able to recognize them when presented as part of a longer list. No instructions as to the mode of memorizing were given. The list was presented but once. Each word was exposed for two seconds.

The recognition list was shown immediately after the exposure list. The subjects were told that all the words in the first (exposure) list were in the second (recognition) list, interspersed with other words. Nothing was said concerning the nature of the distractors. No mention was made that the recognition list was twice as long as the exposure list. The subjects were asked to indicate on a prepared data sheet which words were in the exposure list and which were not. They were told to guess whenever in doubt. Thus a response was made to every word in the recognition list. This list was also exposed but once. The exposure time for each word was three seconds, one second longer than in the exposure list, to permit the subject time to mark a check on the data sheet.

With this manner of presentation and of recording the responses, very close attention was required of the subjects. If a subject was diverted while a word in the recognition list was shown, all succeeding responses would be misplaced on the data sheet. In an attempt to avoid this source of error, the assistant, operating the projection machine, called out the number of each word in the recognition list as it was presented. This may have functioned as a distractor that may have differentially influenced the subjects, but since it was done for all the recognition lists, it should not influence the results.

As the majority of the subjects were not familiar with the experimental set-up, five preliminary practice lists were given in order to prevent as much as possible the variability in the scores that might result from this lack of familiarity with the testing procedure. These practice lists were similar to the lists in Group A in which the confusion words are unrelated to the words in the exposure list. No use was made of these data.

The lists in the experiment proper were presented to the

subjects in the following order: A₁, B₁, C₁, D₁, E₁, F₁, G₁, A₂, B₂, etc., until all the lists were given.

The complete battery required three hours of testing time. In order to offset as much as possible the effects of fatigue, boredom, etc., no test period was longer than one hour.

To increase the reliability of the tests as indices of the ability of the subjects to memorize and recognize words, the experiment was repeated after an interval of two to three months. The average score of the two presentations was then taken as an approximation of the true score.

The number of subjects present at a test period varied from 6 to 35, averaging about 20. A total of 202 subjects, 121 girls and 81 boys, voluntarily completed the experiment. The records for 55 others were discarded because they were incomplete or because the subject was observed to give poor co-operation. The subjects were 15 years of age or over and had completed at least the freshman year of high school.

There are two types of errors possible: errors of commission and errors of omission. The first occurs when a subject indicates a distractor word in the recognition list as having been present in the exposure list; the second, when a subject indicates an exposure list word in the recognition list as not having been present in the exposure list. In this experiment no attempt was made to distinguish between these errors, a subject's score being the total number of correct discriminations between the exposure list words and the confusion words. Stencils were used to facilitate the scoring.

The frequency distributions of the average individual scores of each of the lists for the two presentations are more or less bell-shaped and fairly symmetrical. At the present time it seems reasonable to assume that the ability to memorize this material is normally distributed in the experimental population. This assumption is identical with that involved in the tetrachoric correlation coefficients. While the probable error of a tetrachoric correlation is larger than the probable error of a Pearson product-moment coefficient, the slight increase in accuracy in the use of the latter does not justify the much greater amount of work entailed in its cal-

TABLE 2
INTERCORRELATIONS OF THE VARIABLES

Variable	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5	D1	D2	D3	D4	E1	E2	E3	E4	E5	F1	F2	F3	F4	F5	G1	G2	G3	G4	G5		
A1.....	56	62	60	66	71	67	58	66	65	72	70	40	59	52	31	43	44	51	69	70	62	66	54	38	40	40	48	49	51	56	69	68	55		
A2.....		68	65	74	76	81	71	76	62	62	67	60	67	60	37	41	44	51	63	60	51	70	54	40	53	36	48	51	58	57	66	69	56		
A3.....			68	80	74	67	69	64	75	61	60	59	66	65	32	48	66	58	62	57	48	74	57	57	54	51	47	52	63	66	66	60	60		
A4.....				72	58	56	59	72	61	49	59	55	72	75	27	39	35	42	53	53	44	60	42	34	20	38	42	34	64	55	67	60	61		
A5.....					70	80	80	77	81	73	69	63	79	80	32	38	48	52	59	58	64	79	62	41	42	40	52	47	51	58	59	72	66		
B1.....						79	72	72	81	63	57	67	67	70	42	49	47	53	65	56	65	60	59	51	52	50	59	53	62	54	57	71	59		
B2.....							85	77	80	73	73	68	65	36	50	59	62	67	54	59	68	58	50	48	37	52	40	51	58	51	68	70	58		
B3.....								74	78	63	71	68	76	38	56	56	55	57	52	59	63	57	52	48	43	55	53	48	53	53	63	62	58		
B4.....									75	71	66	71	74	72	37	50	47	51	56	59	65	65	59	48	41	47	45	52	50	52	62	69	68		
B5.....										61	65	79	70	74	47	54	59	65	62	65	68	66	71	55	54	43	44	55	48	63	66	77	67		
C1.....										66	62	62	63	63	30	44	47	43	68	61	55	60	51	43	38	38	43	40	52	52	47	60	61		
C2.....											59	66	67	32	51	48	50	65	67	68	61	55	40	38	30	60	52	60	56	54	63	71			
C3.....												67	70	43	47	55	56	43	51	50	55	38	54	44	47	34	53	38	50	52	60	59			
C4.....													68	27	44	41	54	50	48	52	60	54	50	39	43	40	50	57	60	60	54	60	52		
C5.....															32	43	40	57	62	54	75	62	50	45	34	52	50	53	61	56	66	68	62		
D1.....																40	48	41	29	32	40	37	32	38	51	54	44	41	24	26	27	37	41		
D2.....																	65	54	54	30	50	43	48	30	67	35	60	56	41	41	38	47	37		
D3.....																		60	40	32	50	30	60	60	47	66	54	35	52	50	44	37	40		
D4.....																			47	50	40	48	50	58	51	62	55	45	51	54	48	50	48		
E1.....																				71	68	75	65	55	55	51	41	44	72	66	45	68	65		
E2.....																					72	61	67	44	51	37	52	41	61	56	63	66	62		
E3.....																						71	81	45	52	41	45	48	60	60	57	65	61		
E4.....																							68	51	47	41	54	48	71	57	71	59	70		
E5.....																								52	54	42	47	35	48	54	59	51	62		
F1.....																									68	51	69	65	43	45	43	51	44		
F2.....																										57	79	68	50	55	52	57	48	45	
F3.....																													56	70	22	20	50	35	45
F4.....																														71	48	48	56	52	45
F5.....																															43	37	56	48	52
G1.....																															80	65	80	70	70
G2.....																																69	80	72	70
G3.....																																		78	70
G4.....																																			
G5.....																																			

ulation. Accordingly, tetrachoric correlation coefficients were used in this study.

They were determined for all pairs of scores by means of computing diagrams (6). Each variate was divided at or near the median to avoid the increased margin of error when the division is made at either tail of the distribution. The correlation coefficients were read to two decimal places. They are recorded in Table 2. The mean correlation is .59, and its probable error, computed by the formula given by Kelley (2, p. 258), is .055.

The resulting correlational matrix of order 34×34 was factored to eight dimensions by the centroid method, following the procedure outlined in Appendix I of *The Vectors of Mind* (4).

After the eighth factor had been extracted, the residuals had a mean absolute value of .029 with a standard deviation of .036. Inasmuch as the largest contribution of the eighth factor to any correlation was only .06, and any further factor would probably contribute less, no further analysis was made.

These factors, described in terms of the arbitrary orthogonal axes of the centroid analysis, are not psychologically meaningful. However, a meaningful solution is obtained when the factorial matrix has been rotated so that the number of zero entries is maximized and so that the non-vanishing entries are positive. In this study the graphical method (4) was used in an attempt to transform the arbitrary orthogonal matrix of the centroid analysis into orthogonal simple structure.

Since the resulting transformed factorial matrix (Table 3) is orthogonal, the factors are independent of one another. It will be noticed that there are no zero entries in the first column of this matrix, indicating that the orthogonal structure found is not overdetermined and therefore not unique. However, the orthogonal structure found does not seem unreasonable. All of the tests in the battery are similar in that they involve the visual perception, memory, and visual recognition of words; all were appraised in the same manner, etc. As is to be expected, all of the correlations are positive

and fairly high. In fact, if the transformed matrix did not show a general factor in this experimental set-up, we might well question it.

TABLE 3
TRANSFORMED ORTHOGONAL MATRIX

Variable	I	II	III	IV	V	VI	VII	VIII
A1.....	.72	-.01	.13	-.05	.21	.00	.32	-.07
A2.....	.77	-.04	-.06	.11	.30	.22	.00	.01
A3.....	.65	.07	.03	.23	.36	.40	.20	.06
A4.....	.67	-.15	-.15	.10	.27	.05	.36	.24
A5.....	.82	-.15	-.02	.04	.25	.29	.04	.08
B1.....	.81	.06	.05	-.01	.40	.12	.00	-.03
B2.....	.81	-.02	-.01	.00	.07	.43	.03	-.07
B3.....	.82	.02	-.02	-.06	.05	.37	-.05	.07
B4.....	.82	-.09	.04	-.06	.12	.16	.13	.23
B5.....	.82	-.01	.12	.04	.05	.36	-.04	.22
C1.....	.79	-.09	.03	-.12	.25	.14	.07	-.12
C2.....	.84	.03	-.04	.05	-.10	.05	.23	-.05
C3.....	.71	.03	-.05	-.07	-.02	.31	-.03	.38
C4.....	.74	-.15	-.04	-.02	.14	.23	.20	.13
C5.....	.79	-.03	-.07	.12	.13	.17	.06	.19
D1.....	.37	.35	.13	-.05	.21	.13	-.02	.24
D2.....	.57	.46	.13	-.17	-.04	.16	.25	.00
D3.....	.43	.44	.05	.05	.06	.57	.26	.06
D4.....	.56	.32	-.05	.01	.00	.35	.26	.18
E1.....	.72	.01	.30	.15	.12	.09	.29	-.33
E2.....	.75	.07	.28	.09	-.05	-.06	.28	.03
E3.....	.75	.02	.59	.08	-.01	-.05	.03	.05
E4.....	.71	.00	.18	.21	.34	.20	.23	-.02
E5.....	.64	.10	.53	.11	-.01	.26	.06	.11
F1.....	.54	.51	.07	.08	.02	.28	.09	-.04
F2.....	.58	.63	.13	.22	.04	.12	-.04	-.05
F3.....	.41	.53	.13	-.04	.34	.03	.05	.40
F4.....	.61	.65	-.04	.10	.02	.07	.17	-.05
F5.....	.61	.57	.04	.08	.09	.04	-.06	.17
G1.....	.64	.01	.07	.54	.10	-.02	.37	-.05
G2.....	.63	-.04	.15	.50	.00	.27	.28	.03
G3.....	.68	.07	.02	.36	.04	.09	.10	.36
G4.....	.83	.01	-.02	.43	.09	.02	.06	.01
G5.....	.72	.03	.10	.33	.08	.02	.15	.25

The interpretations of the psychological significance of all of the factors in Table 3 cannot be made with certainty. There is, of course, no necessity to name and define them, but unless it is possible to do so their isolation is not of much psychological significance. Therefore tentative interpreta-

tions will be made, if possible. These are not to be considered as final definitions of the factors, but rather as in the nature of further hypotheses requiring verification.

Factor I has large and significant loadings on every test. It is, therefore, a general factor for these materials, and it is possible that it may have a wider degree of generality than is indicated by these tests. With the present experimental set-up there is no way to determine sharply the limits of this factor. For the present, it can only be defined in terms of the general characteristics of these materials and operations. Accordingly, it is termed a general recognition memory factor for words of these characteristics.

In a recent comprehensive study Thurstone (5) includes in a battery a recognition test of individual words with specially selected lists of distractors. He reports that a factor M (memory) and a factor W_I (word facility) each have appreciable loadings on this test. Inasmuch as there were no tests included in the present battery which did not involve the use of words and memory, it is impossible to isolate similar factors in this study. If the tests in the present battery had been included in Thurstone's study, it is possible that the general factor found in this study would have been split up into his memory and word facility factors.

The simplest explanation for Factors II, III, and IV is that specific visual cues are involved in each. However, there are alternative explanations for Factors II and IV, and these will be discussed individually.

An alternative explanation for Factor II is that it may be a restricted vocality factor. This factor has high loadings for all the tests of Groups F and D and for none of the others. In the tests of Group F the exposure word and its distractor differ only in vocality; in the tests in Group D, they differ in vocality and meaning. In both groups the related words differ in vocality, and there is, therefore, some justification for naming it vocality. It would not be surprising to find vocality is a function involved in the visual recognition memory of words in this experiment for a number of the subjects were observed to move their lips, silently enunciating the

words in their attempt to memorize them. But since vocality might also have been used to advantage in tests in Groups A and C a vocality factor might be expected to have loadings in the tests in these two groups if individuals were consistent in enunciating all the words. Factor II has zero or very small loadings on these tests, and therefore defining this factor as vocality might well be questioned.

The pairs of words in Groups A and C differ in vocality. It does not follow, however, that because certain cues are present they will necessarily be used. The subjects will undoubtedly have a tendency to use whichever method makes it easiest for them to differentiate the words of a pair. Since the words were presented visually, it is probable that the majority of the subjects attempted to use visual cues. By means of visual cues, it is possible to distinguish fairly readily between the words of a pair in the lists in Groups A, B, C, E, and G. On the other hand, the related words in Groups F and D are alike in spelling, differing (from the standpoint of vision) only in syllabication and in position of the accent mark, and cannot be distinguished as readily on the basis of vision. It would appear, then, that vocal cues were used to advantage in this experiment only when the visual cues were not adequate.

Factor III has large loadings on tests E₃ and E₅; the next highest loadings are on E₁, E₂, and E₄, in the order named. In these lists the only difference between the related words is in spelling. Accordingly, the subjects could not distinguish between them if they used vocality or meaning, but they could if they used visual cues. Visual cues is a class name for visual distinctions, and there may be a number of these visual cue factors. Since it would be of interest if the visual cues involved in this factor could be specifically determined, the material comprising these tests was further investigated. This revealed that of these tests E₃ has the largest number of pairs of words with the same letters but with an inversion of the letters 'e' and 'r,' whereas E₂ and E₄ have the smallest number, and E₃ has the smallest average number of letters not common to the words of a pair,

whereas E2 has the largest average. This would seem to indicate an ability to utilize the internal structure of the words, or the arrangement of the letters, as contrasted with grosser visual cues and non-visual cues. While this is not proof that these cues are the only ones involved in this visual factor, it is suggestive that they are at least involved.

The fourth factor has large and significant loadings in all the tests in Group G and in no others. As has been pointed out, this factor may indicate an ability to use a specific visual cue. An alternative explanation, however, is that it indicates an ability to utilize a specific meaning in the memorization and recognition of a word. Since meaning could also have been used to advantage in the tests in Groups A, B, and D, why did this factor not have significant loadings in these tests? There are at least two possible explanations, the correctness of which can only be determined by further experimentation. In the first place, the subjects may have found it convenient to use meaning when it was specified, as was done in the tests in Group G, but found it easier to use another method when the meaning was not given explicitly. Because meaningful cues are present does not mean necessarily that they are or must be used. The second explanation, to which the writer would lean, is that a different function is involved when a subject passively uses meaning when it is specified for a word than when a subject actively recalls and uses the meaning of a word even though it is not specified, as must be done if meaning is to be used in the tests in Groups A, B, and D. It is reasonable to assume that there are many more individuals who can appreciate the meaning of an object or event when it has been pointed out to them than there are individuals who have originality enough to determine of their own efforts the meaning of the object or event. The two meaning abilities may be uncorrelated in which case another factor would be expected to be found that may be interpreted as active meaning. Such a factor may be VI.

The remaining factors, except Factor VI, are less significant than the preceding ones, and they probably cannot

be differentiated from the variable errors and certainly cannot be named with confidence. It is probable that the data did not justify the number of factors extracted from it. In the preceding factors the interpretations were made as though the only source of incorrect response is to be found in the relation between the paired words. It is obvious, of course, that there are other sources of error as well. If similar sources of error are present in two or more tests, but not in all the tests, the end result may be a factor whose nature is not readily discernible from the tests in which the factor has loadings. There were occasional disturbances in the corridor due to basket ball games, etc., which could not be controlled. The recognition tests used in this experiment are particularly sensitive to these external distractors because of the manner of presentation and of recording the responses. Since the number of subjects present in a group at one time varied from six to thirty-five, it is probable that the subjects in one or more of these small groups were influenced by external distractors on certain tests and not on others. The end result may be a factor or factors whose nature would not be evident unless a comparison could be made with the tests being given at the time such external distractors occurred, but this cannot be done since no record was kept of these distractors. With these and other considerations in mind it would be surprising if all the factors could be satisfactorily interpreted. As a matter of fact, no interpretation making psychological sense could be made for Factors V, VII, and VIII.

As suggested in the discussion of the fourth factor, the sixth factor may be interpreted as 'active meaning.' This factor has significant loadings on the last two tests in Group D; on the second, third, and last of Group B; and the third test in Groups A and C. This factor may indicate an ability to learn to utilize the meaning of a word in its memorization, even though that meaning is not explicitly given, since in all the tests in Groups A, B, and D meaning could be utilized to discriminate between the exposure word and its related word in the recognition list, and since this factor does not have significant loadings in the first two tests of Groups A

and D, and the first test in B. This learning would imply a more or less active attempt on the part of some of the subjects to use meaning for the memorization of a word under the conditions of the experiment. It is the opinion of the writer, therefore, that there is some justification for interpreting this factor as 'active meaning' or some comparable term. This interpretation, however, can only be tentative subject to verification as there are a number of objections to it. The presence of a loading on test C₃ would require explanation, as would also the absence of loadings on B₄, A₄, and A₅, and the fact that D₃ is greater than D₄. In C₃, even though the related words are synonyms, there nevertheless is some shade of difference in their meaning, and it is possible that a number of words in the exposure list have other more familiar associations for some of the subjects than the synonymous distractor word used, in which case meaning might be used to advantage. The explanation of the other discrepancies is not so apparent.

CONCLUSIONS

The assumptions were made that memory may be divided into rote and logical memory and that rote memory may be further divided into visual and vocal memory. Since the interpretations of the factors found are equivocal the truth of these hypotheses is not definitely established.

The simplest interpretation of Factors II, III, and IV is that they are three different visual factors. If this is correct, the experiment demonstrates that there are a number of visual memory factors instead of the single visual factor postulated.

An alternative interpretation for Factor II is that it is vocality. If this is correct, it would appear that the subjects resorted to vocality under the conditions of the experiment only when vocal cues were emphasized and visual cues were minimized.

An alternative interpretation for Factor IV is that it is a logical factor in which meaning is explicitly given. If further research verifies this, and the tentative interpretation of Factor VI as being a logical factor involving learning to use

the meaning of a word even though the meaning is not explicitly given, it would appear that logical memory is itself not unique, but rather complex.

If the alternative interpretations of Factors II and IV are correct and if Factor III is a visual factor, the experiment has differentiated between a rote and a logical factor, and the rote factor is further subdivided into a visual and a vocal factor as postulated.

From the statistical analysis, it appears that a general factor, common to all the tests in this battery, is by far the most important single factor involved in the memory of words. Further research will be necessary to demonstrate whether this factor has a greater degree of generality than is indicated by the tests included in this battery.

Three factors appear whose psychological significance is not apparent.

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